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# ERECT VISION

FROM AN

# INVERTED IMAGE.

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'o determine how an inverted image on the retina occasions a percep-on of an erect object "has been long a problem among the learned."* arious explanations have been given by different physiologists and hilosophers. The theory most generally received at the present day, that founded on the law of "visible direction."† In this theory it eems to be assumed as an ultimate fact, that the mind perceives what irection is perpendicular to the retina. Some are satisfied with as-uming, no less gratuitously, that we have a direct perception of the irection in which the rays of light emitted from objects come to the ye; as though the mind could, by a magical exploring power, travel ut of its habitation, and feel along the course of the rays. We find such ews, not only in popular works on natural philosophy; but Magendie— writer seldom satisfied with superficial or inexact views—remarks, iat "We believe, instinctively, that the light passes in a right line, and iat this line is a prolongation of that pursued by the ray which has en-red the cornea." If others refer this perception of the course of the ys to experience, the explanation is vague; the mode in which expe-ence determines this has not been satisfactorily explained. If they eny any power of determining direction by the eye, independently of ie sense of touch, they overlook the muscular sense of the ocular mus-les. Some have maintained that infants see objects inverted. Others ave pronounced erect vision from an inverted image, an inexplicable henomenon. In this last class we may place Prof. Dugald Stewart and )r. Abercrombie. The latter remarks that, "All that can properly be iid appears to be, that such is the constitution of our nervous system." re we then, with these philosophers, to regard this as an ultimate fact, ne not susceptible of being analyzed and referred to the same class with thers more simple and more general?

It is in the first place necessary to state that the subject requires to be onsidered in a twofold view—viz., First, in regard to the relative posi-on of objects as compared with the earth or with the observer at rest; econdly, as to the relation between this position and the direction of ur own voluntary motions.

Let us first consider it in the first sense, which appears to be that in 'hich the problem is generally understood by those who have attempted solution, as well as by those who find a difficulty in conceiving how an iverted image can do otherwise than give a perception of an inverted oject.‡

* Brewster's Optics. † Ibid.

‡ Even Magendie, who considers it an assumption wholly unsupported by proof, iat infants see objects reversed, seems nevertheless tacitly to admit its possibility.

When we have a just idea of the signification of the terms erect anc inverted, it will not be difficult to discover that the perception of erect ness in an object involves a principle which is more elementary, anc which is not confined to vision. If we show that the same principle ex tends to the sense of feeling, we shall have advanced at least one ste in the investigation of this apparent anomaly.

Now considered without any reference to the course or bearing o our voluntary motions—i. e., reference to the particular direction i which the eye or hand is to be moved to trace it—an object appears erec or inverted only with reference to some other object, with reference t the earth for example, or with reference to the body of the observer. I I am conscious of being erect, and if I perceive another individual i the same position with myself, I perceive him to be erect also. Nov the obscurity in which the theory of the perception of position has ap peared to be involved, has resulted from the confusion which has bee introduced by comparing one object with the image of another, instead o comparing objects with objects, and images with images, or in othe words, from comparing the perception of one object with the sensation pro duced by the image of another, instead of comparing perceptions wit perceptions, and sensations with sensations. If I am standing, and man stands erect before me, I do not compare the sensation produced b his inverted image with the perception produced by the inverted imag of my own body; but I compare the sensations produced by the two images

It is easy to conceive that our minds might be so constituted, that th impressions made on any two contiguous points of our organs of sens might be attended by a perception of contiguity in the objects, and tha distance between the points impressed—i. e., the intervention of inte mediate points of the organ—might be attended with the perception c distance between the objects. Surely no one can conceive any reaso why an impression on two contiguous points should give a perception c remoteness. If it gives any perception of location, it must be that c contiguity. This, if a principle, would suffice for showing the correc ness of our earliest notions of the relative position of external objects But instead of viewing this as an ultimate principle, I derive it fro others more elementary, and consider the perception of angular distanc and in one sense that of contiguity, as dependent on muscular feelin maintaining, however, that after a very short experience, simultaneou impressions on contiguous points give a perception of contiguity, an those on remote points a perception of remoteness, and that consequentl it is impossible that erect objects could appear inverted when their part are viewed either successively or simultaneously. To leave nothin vague, let us consider what is the fundamental idea of contiguity and a preliminary to it—of contact. If I place my finger so near an object a to feel its resistance, I touch it. This is my fundamental idea of co tact, yet I can conceive that a closer proximity might be required in ord that a being differently constituted should receive the same sensatio and I believe that no two particles of matter are in absolute contac The above, therefore, is not absolute contact, strictly and mathematicall considered, but it is physical contact, i. e., such a degree of approxima tion as produces on us a sensible repulsion.

Now, to examine an object by the sense of feeling, requires conta with the organ of feeling. If I move my finger continuously along th surface of an object, so as to be in contact with its different points in su

ssion, my muscular sense informs me not only of its repulsion, but of e different degrees of motion requisite for the examination of different rts. Any two parts whose successive examination by the same point the finger requires no movement, or the least appreciable movement of e finger, I consider contiguous. This is the elementary idea of contiity, as perceived through the medium of feeling.

Let us apply this principle to the eye. The finger—eminently the at of the sense of touch—sustains a relation to the body in general nilar to that which the central part of the retina sustains to the retina general. This central part is the immediate organ of distinct vision. he image, here formed in the axis of the eye, is that which gives the ost distinct perception ; and hence an accurate ocular examination of an ject of sensible extent requires some rotation of the eyeball, by eans of its muscles. Adaptation to distance in a given line also reires muscular action. Hence, if I direct my eye successively to the fferent parts of an object, my muscular sense informs me of the differt degrees of motion requisite for the examination of different parts. ny two parts whose successive and accurate examination requires no uscular action, or the least appreciable muscular action, we consider ntiguous. This is the elementary idea of contiguity, as perceived rough the medium of vision. If, with the eye or finger, we trace an ject from any given point of it, we consider its other points as more or ss distant, according as their examination requires a greater or less exnt of muscular action. Whether this extent is greater or less, we are formed by the muscular sense.

The perception of the true relative position of external objects is referle to the foregoing principles, which are common to sight and feeling. et us make the application to vision. Suppose I am viewing a man ho is standing erect on a horizontal plane—the image of the man's feet my retina is certainly contiguous to the image of the plane—I therere perceive the actual feet to be in contact with the actual plane. Of ll parts of his image, that of his head is most remote from the image of e plane. I therefore necessarily judge that the actual head is the part f the body most remote from the actual plane. In short, I perceive that e man is erect and not inverted ; in other words, that he stands on his et, and not on his head.

The same principle is applicable if the body of the observer—instead f the earth—be considered as the standard of comparison. If, whilst I m conscious of standing erect, I include, in the same field of vision, nother man's body and a part of my own, and if my image and his have similar position, it follows, from the foregoing principles, that he must evitably appear erect, although his image is reversed, with respect both his body and mine.

We see then that there is not only a reason why objects appear erect, ut why it is impossible that the eye could have been so constructed as make them appear reversed. If the eye had consisted of an optical pparatus, which, like a camera lucida, should have changed the position inety degrees, instead of one hundred and eighty, everything would ave appeared precisely as it does at present; simply because the images f all bodies—our own included—would have had the same relative posiion that they now have.

That we have no direct perception of absolute position in space, is vident from every day's experience ; for the globe we inhabit is at any

one moment reversed with respect to its position twelve hours previou yet, from a comparison of objects on its surface, we perceive no chan of position. So forcibly and habitually is this impressed upon our mind that thousands, who are convinced of the earth's rotation, find it dif cult to realize, whilst the mass of mankind are with difficulty convinc of the fact; and no man would have discovered it, if no world but th had existed.

Whether we consider the perception of contiguity as resulting direct from the contiguity of the parts impressed, or mediately through the mu cular sense, it is evident that this perception must be one of the earlie elements of our knowledge of position, and that there neither is, nor ca be, any kind of eye so constituted as to make erect objects appear inve ed, either with respect to the earth or an erect observer.

If we had made no reference to muscular action, the greater part of th foregoing reasoning would have been the same; and it is true, that, aft a very short experience, we can judge of contiguity and angular distan from simultaneous impressions. The variable distinctness of these f different parts of the retina affords data. But as this distinctness dimi ishes equally in all directions from the centre, it affords no data for imm diately determining in what direction we should move the eye, in order obtain a distinct view. This leads us to the second division of our su ject.

Let us now consider the question in its second sense. This is a kir of practical sense in which we may speak of knowing the position objects, i. e., knowing in what direction to roll the eye, or move the han in order to trace the object from top to bottom, or bottom to top, from rig to left, or left to right, &c.

The particular modes in which different directions and different degre of angular distance are estimated by muscular action, it is not essenti here to consider. In the "Physiological explanation of the beauty form,"* I have recognized in the vision of objects, the necessity of tra ing them by means of the ocular muscles. This art, with its resultir knowledge and pleasure, is acquired only by experience. The young in fant, though created with mental faculties for the estimation of form ar magnitude, and for the enjoyment of beauty and grandeur, has no actu perception of either. In the investigation before us, we are chiefly co cerned with the mode of estimating direction.

Suppose a child who has acquired the use of his hands, but who ha been blind from his birth, to have the sense of sight given him by a su gical operation. At first he would be utterly unable to point towards an object, of whose situation he had no knowledge except that given by th eye. For example, suppose him looking at a star through a tube hel near his eye by another individual. He would be unable on a first a tempt, to direct his finger or arm toward the star, and would be as liabl to move it in the opposite direction. If a higher and a lower star wer visible through the same tube, and his finger were already directe toward one of them, he would be utterly unable to decide as to what kin of volition was necessary in order that his finger should move towar the other. He would be liable to the mistake of moving it up instead c down, to the right instead of the left, and in directions at all possible ar

* Transactions of the Medical Society of the State of New York.

es with the required direction. It would be the same with the different ırts of a single object. Suppose whilst he is pointing to the centre of ıe moon, he is required to point to its upper limb; he would in attempt- g it, be as liable to commence the motion in the direction of one radius the disk as in another. In this sense of knowing its position, he has knowledge of it at all; in this sense he neither sees it erect nor reversed. e can neither direct the hand nor the tube to any required part.

In directing the eye itself by the action of its muscles, his difficulty ould in the first instance be as great, and subsequently much greater. aving no experience in this kind of motion, the direction of it would quire a longer education. His condition as an observer, engaged in recting either the tube or the eye, would be infinitely more perplexing an that of an astronomer furnished with a telescope and required to ıange the direction of its axis from one star to another in the same field, ıving no information as to whether it gives erect or inverted images, ıd having no guide except the apparent positions as seen through the lescope. The first motion of the astronomer would be either in the oper direction, or exactly the reverse; the novice in vision would be ıble to err in an infinite number of directions. We are not to infer that is confusion would be in the least degree owing to the inversion of the ıage on the retina; were the image erect, the difficulty would be pre- sely the same. In both cases, experience would be required for the oper direction of the eye, and for the proper direction of the motions the body. This experience we all acquire in infancy.

Our conclusions then are, first, that infants cannot see objects reversed; condly, that the inversion of the image does at no period of life increase e difficulty of obtaining correct perceptions; thirdly, that any position the image gives a correct perception of the relative position of objects ith respect to each other, the earth and ourselves included; fourthly, ıat neither the erect nor any other position of the image could afford us ıy direct and immediate aid in tracing the object with the eye or the and.

I will explain how a correct perception of position in the first sense— e., the position of objects with respect to that of other objects, and of ır own bodies considered objectively, aids the acquisition of it in the cond sense; i. e., in the sense of knowing what volition to make in der that our organs—as the hand or the eye—may move toward them.

I will illustrate it by the use of the telescope. When a young astro- omer uses a kind of telescope to which he is unaccustomed, he may at rst move it in the wrong direction, in attempting to bring a star nearer ıe centre of the field; but perceiving that the effect is to remove it far- ıer from the centre, he learns to correct his mistake; and after repeated orrections, he acquires facility in directing the instrument.

Now, in what I have said of original ignorance as to the proper direc- on of the hand, I have not only confined it to first attempts, but supposed ıe view of the hand, as well as of other objects, to be cut off by a tube. et us see how, under ordinary circumstances, our education in regard a knowledge of position, in the second sense of the terms, is facilitated y that correctness of perception which I have proved necessarily to xist in relation to the first sense. I have said, that proximity and re- ıoteness of two images, respectively give us perceptions of proximity ıd remoteness in the objects. Now suppose the view of the hand un- bstructed. As the novice in vision moves his hand, its image on his

retina may either approach the image of the star or it may recede from If it approaches, then the real hand also approaches the direction of t real star; if the images separate, so do the directions of the objec Thus, as he neither sees objects inverted, nor motions reversed, h visual impressions afford a correct guide in the education of his har In learning to direct his hand, he therefore has the aid of a princip similar to that which the astronomer employs in learning to direct l telescope.

The following recapitulation may afford a brief explanation of ere vision from an inverted image. When objects are in contact, their imag on the retina are in contact; when the objects are more distant, their imag are more distant. Hence these images give an approximately corre perception of the relative distance of objects and parts of objects; and man standing on a horizontal plane, cannot appear to have his head the plane and his feet in the air. Thus after a slight experience, the i fant observer has some knowledge of angular distance, i. e., is conscio of the necessity of some volition in changing the objects of distinct visic Yet of that specific character of the volition which is requisite in ord that the motion may have the requisite direction, he may still be ignora In attempting to trace the object upwards, he might move the eye dow wards, or to the right or left. He acquires by subsequent experience t art of directing the eye; and, in acquiring this art, he is aided by t correctness of his motions in regard to proximity and distance, and guid by the muscular sense.

The mind is not like an observer stationed behind the retina to co pare the position of the image with that of the eye; as we neither s objects inverted nor motions reversed, and know, from the increasing di tinctness, when the direction of the eye is approaching that of the obje we learn to regulate its motions. The experience essential for perfe ing our knowledge of visible direction and position, is in the use of t muscles which change the position of the eye. These alone would su fice; those which move the head are auxiliary. This theory of t knowledge of direction and position differs from that which refers it e clusively to the education of touch. Touch is often auxiliary, but nev essential. A knowledge of visible direction would be acquired by infant, though its hands were immovably confined.

I shall conclude with an examination of "the law of visible directio as applied to the explanation of erect vision. The reasonings and exp riments here referred to are those found in Brewster's Optics. The la is this: the "visible direction" of any small object or point, is in a li drawn at right angles to the retina from the point of the retina on which image is situated. Sir David Brewster,—a philosopher highly and just respected for his numerous and valuable contributions to optical scienc and regarded as the highest authority in matters pertaining to the eye- affirms that "this law, deduced from direct experiment, removes at on every difficulty that besets the subject" of erect vision. I am not able discover, in what he denominates "this important law of the physiolo of vision" anything which, if true, has any bearing upon the theory erect vision—anything which has the slightest tendency towards t solution of the real problem, nor in the experiments adduced in supp of this law, any proof of its exact truth. The true theory of visible dire tion is intimately connected with the true theory of erect vision. A tr

anation of the reason why we see all objects and all their parts in r actual directions, is an explanation of the reason why we see them ıeir actual position. This is what I have attempted. To show the that an object is seen in a certain direction, is one thing; to show reason why it is seen in that direction, is quite a different thing. lembert must have seen this distinction when he admitted as a fact direction,—on which Sir David Brewster insists as an explanation, would "not undertake to explain" why the object is seen in this ction.* Should we state that any point is seen in the direction of a drawn from its image on the retina to the common point of intersec- of the axes of different pencils of light, this would be no explanation isible direction nor of erect vision. The statement would have the e merits and demerits as this other celebrated law of visible direction, it would be both true and superficial. It would be equally adapted to ılar use. A single glance at a diagram of the eye and the refracted would produce general conviction. How could any one doubt that two ends of the object must be found in the direction of the axes of pencils of light which had emanated from them? Most persons ld exclaim, "Surely it must be seen erect." Yet, in recent and ıly-respectable works, and on the authority of Sir David Brewster, ıe highest authority in such matters, the law of visible direction is rred to as affording the most satisfactory explanation of erect vision.† could be proved that the perpendiculars to the retina show the exact ction in which objects appear, still the reason why objects appear in direction would be as far from being explained as before. Can any dard of direction give any knowledge of direction, unless we have e idea of the direction of the standard? We might as rationally pre- e that we could obtain an exact idea of the length of objects by the ication of a measuring rod of whose length we were totally ignorant, uide a ship by the needle without a knowledge of its declination or ation.

assing over the gratuitous assumption which seems to be implied, to which I formerly alluded, viz., that we have an instinctive idea of position of these perpendiculars—let us consider the facts relied on he establishment of this theory. The first is this:—An object seen ugh a small segment of the pupil appears in the same direction as if ı through the whole. In other words, the lateral or peripheral por- s of the pencil will, if concentrated on the same point of the retina as central parts, give a perception of the same direction as the central , or the same as the whole pencil.

ow, the only legitimate inference from this undoubted fact, is, that apparent direction of an object does not depend upon the direction in ch the light arrives at the retina, but simply upon the situation of the of the retina impressed.

ll these supposed confirmations are but repetitions of the same gene- fact. If a more permanent impression is made on the retina, so as to luce a protracted vision of an object after its withdrawal, this ocular ctrum must of course, on any theory, obey the same law of apparent ction as the real object. Yet Sir David Brewster thinks it a con-

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Vide Proceedings of the British Association for 1838, in which Dr. Brewster butes the law to Dechales, Porterfield and Reid.

Elliotson's Physiology.

firmation of this law, that the ocular spectrum seen on shutting the e after viewing a black paper figure of a man held up in the directio the sun, appeared erect or inverted according to the position of the obj

He also adduces the fact that "if we press the eyeball at any where the retina is, we shall see the luminous impression which is duced, in a direction perpendicular to the point of pressure." On th would remark, that when mechanical pressure on the eyeball produ the perception of light, the direction of the imaginary external lumin point from which the light appears to proceed, must appear to be same as that from which light must have actually proceeded, in orde fall on the part of the retina mechanically pressed. Whether it be an ac luminous impression from without, or mechanical pressure generating i tation or light within, the law which I have stated applies; viz., the of connexion between apparent direction and the locality of impressi The retina being so constituted as ordinarily to give no perception that of light; then if a pin-head excites it through the other coats, c star through the humors, in either case there appears a luminous poi and this point, whether real or imaginary, must appear in the same dir tion, if the impressed point of the retina is in both cases the same.

The same law of locality of impression applies to another of David Brewster's supposed confirmations of this law of visible direct by which he explains erect vision. The fact which he adduces is, t pressure on the eyeball changes the apparent direction of objects. explanation is that such pressure "alters the spherical form of the s face of the retina," and consequently the direction of its perpendicul which we regarded as the lines of visible direction; and alters their pl of meeting which is regarded as the centre of visible direction.

In order to test this theory, I resorted to a simple experiment, wh any one can easily repeat, and by which the theory is refuted. I pl a candle at a short distance before me, and look at a more distant obj beyond it. Then, as the light falls on dissimilar parts of the two reti I see two flames. If I then press the right eyeball with the finger; left flame, which is that seen by the right eye, changes its apparent pla Now the problem is to determine whether this change of apparent pl is attributable to a change in the location of the image on the retina, to a change in the form of the eyeball. In one respect, the problem i little complicated, inasmuch as a change in the form of the retina wo generally be attended by some change in the locality of the part i pressed, as well as by a change in the direction of its perpendicular; that even were the axis of vision unchanged by the pressure, Sir Davi explanation would not be confirmed by the effect of pressure in changi the apparent direction. The effect might still be—and so far as deper on change of form undoubtedly is—owing to change of locality in t image. But in order to remove all ambiguity arising from this sour and to render it evident that the change of direction in the object p duced by pressure is not chiefly attributable to a change of form the retina, I modify the foregoing experiment in the following manne Instead of forcibly pressing on the eyeball, I rub the finger gently ov it, so as to rotate the eyeball without sensibly changing its form. T finger being gently pressed on either eyelid, is drawn over the eyeb parallel to its surface. The consequence is that *the change in the app rent position of the* flame *is much greater than* that which results from t most *violent pressure.* Such a result is wholly inexplicable by Sir Da

wster's hypothesis of change of figure; but is precisely what might xpected if apparent direction is changed by moving the image on the ıa, and if pressure on the eyeball produces that change of locality in image. The hypothetical virtues of radii, perpendiculars, and the ntre of visible direction," find no support in this experiment.

'he experiment may be varied in the following manner, so as to dis- se with the two images of the candle, and yet lead to the same con- ion. Shut one eye, and rotate the open eye with the finger in the ner above described. Then all objects will appear to move in the ction opposite to that in which the eye is rolled; in the same man- and for the same reason, that the supernumerary flame did in the eding experiment. For example, if the right eye is rolled to the the panorama of the field of vision moves to the right, for the ges are formed farther to the left, like those of objects situated far- to the right. A similar, though less effect is produced by strong sure. I find that pressure towards the left produces apparent motion ırds the right, and vice versâ. This confirms the conclusion, that effect of pressure depends upon the rotation it occasions. To es- sh this still more conclusively, I direct the pressure more and more wards, and find the effect diminished; and when by pressing simul- ously over different points of the eyeball, I produce a resultant force ost directly backwards in the direction of the axis, I find the apparent ion of objects reduced nearly to zero. This is precisely what should place, if the illusion results from a change in the location of the ge, but is entirely different from what should take place if it resulted a temporary oblateness of the eyeball, and a consequent change in direction of the radii.

is hardly necessary to add, that every change in the location of the ge is not attended with a perception of motion of the object. When- this motion of the image is occasioned by a voluntary motion of the the head, or the whole body, we are conscious of the motion of the n or of our body, and attribute the change of sensation to its true e: in the ordinary rotation of the eye, objects which are with re- t to us actually stationary, appear so. But when a change in the tion of the image results from motions of the eye not produced by muscles which ordinarily produce it—as for example when the eye tated by the finger—we attribute the motion to the object. With rotation—as in the experiment before described—the object appears ove; yet according to the law of visible direction, there should be pparent motion. The law is thus transgressed by nature, and is efore no law. The concession before made in regard to its approxi- truth, applied only to ordinary vision. If the eyeball is, by means ıe finger, rotated to the left, then the perpendicular drawn from the ge on the retina is not directed to the apparent place of the object, passes it on the left side. Experiment appears to me to overturn "law of visible direction," considered as a statement of the direction hich objects actually and in all cases appear. The perpendiculars— ever nearly coincident with the axes of the pencils—have no inhe- power, as perpendiculars, to control our judgment in regard to direc- . But if this law were true in point of fact, it would still afford no anation of apparent direction or erect vision.

*ew York, Sept. 30th,* 1845.